Taylor Run Soil Sampling and Analysis Report

At the request of City staff, Wetland Studies and Solutions Inc. (WSSI) engineers collected on-site nutrient and bulk density samples at the Taylor Run stream restoration project site. Samples were collected on July 27, 2021. Though this project was initiated prior to on-site sampling requirements, this report details potential pollutant (nutrient and sediment) load reductions for the proposed stream restoration project under newly issued DEQ guidance.

The potential pollutant removal benefit of the restoration project was determined in accordance with the Virginia Department of Environmental Quality (DEQ) Guidance Memo No. 15-2005 (Guidance Memo) by applying the appropriate protocols from the 2014 guidance document titled "*Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects*" (Guidance Document). While the original Guidance Document encourages the use of default values for nitrogen and phosphorus loading rates, revisions to Protocol 1 were developed by the Urban Stormwater Workgroup convened by the Chesapeake Stormwater Network in 2020 in a report titled "*Consensus Recommendation for Improving the Application of the Prevented Sediment Protocol for Urban Stream Restoration Projects Built for Pollutant Removal Credit*" (Updated Guidance). This Updated Guidance suggests that bank sediments be tested for nutrient content and bulk density, rather than using default rates. This has since been officially approved by the DEQ for all new stream restoration projects.

According to the Updated Guidance on bulk density and nutrient sampling, WSSI staff collected representative samples at no greater than 500 ft intervals along restoration reaches at Taylor Run. Sample spacing was based on site-specific evaluation. A total of four (4) sites were selected for bulk density and nutrient sampling. Three out of the four sites included one bed and one bank sample for bulk density and three (3) additional samples for determination of nutrient concentrations. The other site included one bed and two (2) bank samples for bulk density and four (4) additional samples for determination of nutrient concentrations, as the bank was approximately seven (7) feet tall.

Soil bulk density testing was performed in compliance with USDA-NRCS Soil Quality Test Kit Guide, Section I, Chapter 4, pp. 9-13. Bulk density samples were collected using a 2" x 2" in-situ soil core sampling device, fitted with a driver hammer and a metal liner to keep samples intact. Field bulk density samples were bagged and labeled during field collection. The samples were taken back to the WSSI Northern Virginia office for processing. The soil samples were then put in an oven set at 110°C for a minimum of 24 hours and weighed until the difference in weight between consecutive weightings was less than or equal to 0.1g. Soil bulk density was calculated as the sample dry weight in pounds divided by the sample size in cubic feet. To determine the bed bulk density, the average of all the bed bulk density samples was calculated. Similarly, the average of the bank density samples determined the average bank density of the stream. For Site 3, where two bank density samples were collected, the average of these two samples was calculated first and then used to calculate the overall bank density average for the stream. Results for bulk density are reported in Exhibit 1.

TP and TN samples were taken at the top, middle, and bottom of each bank, except for Site 3 where four samples were taken at the top, upper middle, lower middle, and bottom of the bank due to

high bank height. A soil auger was used to excavate approximately 25 in^3 of soil from bank areas, with each sample location processed/tested independently. Large rocks and organic matter were removed from samples at the time of collection. Samples were collected in plastic bags, stored in a cooler, and shipped overnight to the lab for testing. TP and TN were analyzed according to acceptable laboratory practices by Waypoint Analytical. Specifically, the Total P concentration was analyzed using the Total-sorbed P – EPA Method 3051 + 6010 (USEPA 1986) and the Total N concentration using the Total N combusting testing (Bremner 1996), as specified in the Updated Guidance, page 21. The average conversion factor for phosphorus and nitrogen was calculated by averaging the nutrient concentrations at each site and then taking the average of the site-specific nutrient concentrations. Results for nutrient concentrations are reported in Exhibit 1.

Exhibit 2 shows the pollutant removal calculations for Total Suspended Solids (TSS), Total Nitrogen (TN), and Total Phosphorus (TP). Table 1 reflects how the site-specific bank bulk density calculated from the on-site samples is used to determine TSS removal rates. Tables 2 and 3 show how the site-specific phosphorus (TPC) and nitrogen (TNC) conversion factors are used to calculate the TN and TP load reductions. Table 4 calculates the TSS load reduction in lb/yr.

A brief summary table comparing prior pollutant removal estimates and revised estimates for Taylor Run is given in Exhibit 3. For this comparison, it was ensured that the same removal efficiency and reach lengths were used, so that the only variables causing the change in removal rates are the on-site samples of bulk density and nutrient concentrations as well as the use of the curve recommended in the Updated Guidance (combination of USFWS and Rosgen data.) Results show a reduction in TSS removal from 554,680.4 lb/yr to 369,706.8 lb/yr, in TN from 632.3 lb/yr to 126.4 lb/yr, and in TP from 291.2 lb/yr to 89.9 lb/yr.

EXHIBIT 1
BULK DENSITY AND NUTRIENT CONVERSION FACTOR CALCULATIONS
TAYLOR RUN

SAMPLED BULK DENSITY AND NUTRIENT CONCENTRATIONS								
Sampling Site	**Position on Bank[1]**	**Bank Bulk Density** (lbs/ft^3)	**Total Nitrogen** (ppm)	**Total Nitrogen[2]** (lbs TN/ton Sed)	**Average Nitrogen** (lbs TN/ton Sed)	**Total Phosphorus** (ppm)	**Total Phosphorus[2]** (lbs TP/ton Sed)	**Average Phosphorus** (lbs TP/ton Sed)
1	*Upper*	77.2	443	0.89	1.00	132	0.26	0.27
	Middle		351	0.70		86	0.17	
	Lower		701	1.40		193	0.39	
2	*Upper*	77.0	411	0.82	0.82	146	0.29	0.35
	Middle		662	1.32		238	0.48	
	Lower		151	0.30		142	0.28	
3	*Upper*	76.4	161	0.32	0.21	94	0.19	0.32
	Upper-Middle		131	0.26		105	0.21	
	Lower-Middle		61	0.12		175	0.35	
	Lower		71	0.14		262	0.52	
4	*Upper*	35.9	512	1.02	0.71	152	0.30	1.00
	Middle		493	0.99		273	0.55	
	Lower [4]		61	0.12		1080	2.16	

Average Bulk Density (lbs/ft^3)	**66.6**
Average TN (lbs TN/ton Sed)[3]	**0.68**
Average TP (lbs TP/ton sed)[3]	**0.49**

[1] *TN and TP samples were taken from multiple locations in each bank.*

[2] *TP and TN were analyzed according to acceptable laboratory practices by Waypoint Analytical.*

[3] *Nutrient concentrations were averaged by site, then site averages were averaged to obtain the overall average.*

[4] *Due to the significant variation in characteristics for the TP sample taken at location 4, the laboratory analysis was rerun to confirm these findings.*

EXHIBIT 2
SEDIMENT LOAD CALCULATIONS
PROTOCOL 1 - PREVENTED SEDIMENT DURING STORM FLOW
TAYLOR RUN

Table 1. Sediment Load Estimate

Reach	Station Name	NBS Adjective	BEHI Adjective	Bulk Density of Soil[1] c (lbs/ft^3)	LBER[2] R (ft/yr)	Bank Length BL (ft)	Eroding Bank Height[3] BH (ft)	Eroding Bank Area A = BH * BL (ft^2)	Sediment Load[4] S = (cAR)/2000 (ton/yr)
Taylor Run Main Channel	BEHI #1	*High*	*High*	66.6	1.00	90	5.0	450	14.99
	BEHI #2	*High*	*Extreme*	66.6	2.50	65	6.5	423	35.23
	BEHI #3	*Low*	*Low*	66.6	0.03	35	1.5	53	0.05
	BEHI #4	*High*	*Very High*	66.6	1.00	70	8.0	560	18.66
	BEHI #5	*Low*	*Moderate*	66.6	0.13	56	4.0	224	0.93
	BEHI #6	*Very High*	*Very High*	66.6	1.75	73	4.5	329	19.18
	BEHI #7	*High*	*Extreme*	66.6	2.50	110	10.0	1,100	91.61
	BEHI #8	*High*	*Extreme*	66.6	2.50	107	8.0	856	71.29
	BEHI #9	*Moderate*	*Very High*	66.6	0.64	26	8.0	208	4.43
	BEHI #10	*Low*	*Very High*	66.6	0.40	26	8.0	208	2.77
	BEHI #11	*Moderate*	*Moderate*	66.6	0.30	46	5.0	230	2.30
	BEHI #12	*Low*	*High*	66.6	0.40	142	7.0	994	13.25
	BEHI #13	*Moderate*	*Moderate*	66.6	0.30	84	4.0	336	3.36
	BEHI #14	*Very High*	*Extreme*	66.6	3.50	35	7.0	245	28.57
	BEHI #15	*Very High*	*Very High*	66.6	1.75	61	9.5	580	33.81
	BEHI #16	*Low*	*High*	66.6	0.40	19	9.0	171	2.28
	BEHI #17	*Moderate*	*Moderate*	66.6	0.30	89	5.5	490	4.90
	BEHI #18	*Moderate*	*Very High*	66.6	0.64	71	7.0	497	10.60
	BEHI #19	*Moderate*	*High*	66.6	0.64	90	6.0	540	11.51
							Existing Reach Length (lf)		1,295
							Total Sediment Load (ton/yr)		369.7
							Total Sediment Load (ton/lf/yr)		0.29

[1] *Average bulk soil density (ρs) of 66.6 lb/ft^3 was measured on site.*

[2] *Lateral Bank Erosion Rates (LBER) were obtained from curve recommended in the Updated Guidance (combination of USFWS and Rosgen data)*

[3] *Measured from Existing Top of Bank.*

[4] *2000 is the conversion rate from pounds (lbs) to tons.*

Table 2. Total Phosphorus (TP) Load Reduction

Reach	Formula	Sediment Load to TP Conversion, TPC[5] (lbs TP/ton Sed)	Restoration Efficiency, RE[6]	Value, TP (lb TP/yr)
Main Channel	TP = S * TPC * RE	0.49	0.50	89.9

Total TP Load Reduction (lb TP/yr)	**89.9**
Total TP Load Reduction per LF of Restoration[7] (lb TP/yr/lf)	**0.07**

[5] *As measured from field samples - see exhibit 1*

[6] *As specified in "Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects". Through success monitoring post stream restoration and concurrence with DEQ there is potential to demonstrate higher removal efficiency and thus greater pollutant load reduction.*

[7] *Based on existing reach lengths.*

Table 3. Total Nitrogen (TN) Load Reduction

Reach	Formula	Sediment Load to TN Conversion, TNC[5] (lbs TN/ton Sed)	Restoration Efficiency, RE[6]	Value, TN (lb TN/yr)
Main Channel	TN = S * TNC * RE	0.68	0.50	126.4

Total TN Load Reduction (lb TN/yr)	**126.4**
Total TN Load Reduction per LF of Restoration[7] (lb TN/yr/lf)	**0.10**

[5] *As measured from field samples - see exhibit 1*

[6] *As specified in "Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects". Through success monitoring post stream restoration and concurrence with DEQ there is potential to demonstrate higher removal efficiency and thus greater pollutant load reduction.*

[7] *Based on existing reach lengths.*

Table 4. Total Suspended Sediment (TSS) Load Reduction

Reach	Formula	Ton to Pound Conversion, CNV (lb TSS/ton TSS)	Restoration Efficiency, RE[5]	Value, TSS (lb TSS/yr)
Main Channel	TS = S * CNV * RE	2000	0.50	369,706.8

Total TSS Load Reduction (lb TSS/yr)	**369,706.8**
Total TSS Load Reduction per LF of Restoration[6] (lb TSS/yr/lf)	**285.5**

[5] *As specified in "Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects". Through success monitoring post stream restoration and concurrence with DEQ there is potential to demonstrate higher removal efficiency and thus greater pollutant load reduction.*

[6] *Based on existing reach lengths.*

EXHIBIT 3
POLLUTANT REMOVAL SUMMARY TABLES
DEFAULT RATE VS ON-SITE SAMPLING
TAYLOR RUN

Table 1. Total Pollutant Removal

Parameter	Removal Based on Default Rates	Revised Removal Based on Site Sampling
TSS Removal Estimate (lb TSS/yr)	554,680.4	369,706.8
TN Removal Estimate (lb TN/yr)	632.3	126.4
TP Removal Estimate (lb TPN/yr)	291.2	89.9

Table 2. Pollutant Removal per Linear Foot of Stream Restoration

Parameter	Removal Based on Default Rates	Revised Removal Based on Site Sampling
TSS Removal Estimate/LF (lb TSS/yr/lf)	428.3	285.5
TN Removal Estimate/LF (lb TN/yr/lf)	0.49	0.10
TP Removal Estimate/LF (lb TP/yr/lf)	0.22	0.07